Fermilab
MAIN INJECTOR DEPARTMENT

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To: Greg Bock, NUMI Project Manager

Dear Greg:

Attached are the measurements performed in the Main Injector to characterize the proton beam quality for NUMI. We have performed these measurements on $2B (150 GeV injection cycle for TEV) and $29 (120 GeV injection cycle for pbar production) cycles in the Main Injector. In both cases no feed back system has been used. So we expect to improve on these measurements as time is spent on developing this hardware in FY02/03. On page 6 of these notes you will find our guess of the NUMI beam quality as extrapolated from present measurements. Transverse emittances are expected to be less than 40 π mm-mr (normalized) and longitudinal less than 1 eV-sec. These are 95% emittances. This is a factor of two worst than what we do today. I expect that the present quality will improve by about 50% with feedback systems. The MI momentum regulation is of the order of 10^{-4}.

In all of these one must consider that there will be accidental pulses. These pulses will fill the MI aperture due to failure of one or the other component.

If you have any questions about these measurements, please let me know. We are in the process of putting hardware to measure beam tails.

Thanks.

cc: B. Baller
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2B Longitudinal Emittance Studies in MI with Booster Longitudinal Dampers off

Chandra Bhat and Alberto Marchionni

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		8GeV				150 GeV Before Coalescing				150 GeV after Coalescing				
MI Beam	I:IBEAMM	RMSW	W95%	el	dp/p	RMSW	W95%	el	dp/p	RMSW	W95%	el	dp/p	emit-growth
# of BT	E9	(ns)	(ns)	(eVs)	(%)	(ns)	(ns)	(eVs)	(%)	(ns)	(ns)	(eVs)	(%)	from 8-150 GeV
14	380	2.02	7.67	0.190	0.18	0.78	3.06	0.23	0.03	3.25	12.64	3.03	0.11	1.2
12	360	2.02	7.50	0.182	0.18	0.80	3.11	0.24	0.03	3.35	12.90	3.12	0.11	1.3
10	335	1.79	6.91	0.156	0.16	0.71	2.87	0.20	0.03	3.36	13.09	3.18	0.11	1.3
8	265	1.72	6.65	0.147	0.16	0.72	2.90	0.21	0.03	3.30	12.69	3.04	0.11	1.4
6	205	1.49	6.19	0.128	0.15	0.62	2.64	0.17	0.03	3.22	12.39	2.94	0.11	1.4
												Average		1.3

Transverse emittance measurements on $2B Cycle

		8 GeV		150 GeV	
#Booster turns	Intensity (x 10^9)	Hor	Vert	Hor	Vert
6	205	10.7	10.6	14.1	12.4
8	265	12.3	10.9	13.8	14.2
10	335	12.4	11.7	16.5	15.2
12	360	13.3	12.4	17.2	14.4
14	380	15.1	14.4	19.5	16.6

Longitudinal Emittance of $29 Cycle

I	ε @8.9 GeV	ε 120 GeV
$x10^{12}$	eV-sec	eV-sec
3.0	0.16	0.31
3.6	0.17	0.37
4.0	0.17	0.36
4.25	0.17	0.36
	~ 0.2 eV-sec	~0.4 eV-sec

This is the present situation on $29 cycle. This growth of a factor of 2 can be reduced by better tuning and feedback system.

Transverse Emittance $29 Cycle

I	ε_h	ε_v	ε_h	ε_v
x10 ^{12}	8.9 GeV/c		120 GeV/c	
3.0	13	13	20	13
3.6	13	13	22	13
4.25	15	14	23	14

There is no significant growth in vertical plane. Horizontal plane is growing by a factor of 2. Study is needed to control this.

NUMI Intensity and Beam Quality Projection

2.5×10^{13} PPP		Measured
~ 40 π mm – mr	$\varepsilon_h, \varepsilon_v$	(25)
~ 1.0 eV– sec	ε_e	(0.5 – 0.6)

10^{-4} Momentum Regulation

We need to learn how to run at these high intensities in the Main Injector.

Numi Intensity Points

- Higher Intensity is bad
- Mixed mode is (maybe) better Beam loading
- Expect to fix horizontal growth
- Expect to fix longitudinal growth
- Larger aperture beam line is better
- Passive (collimator) protection is better
- Aperture of MI is 500 π mm-mr and ± 0.7 % at 120 GeV